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(54) IMPROVEMENTS IN OR RELATING TO THE COATING OF RAZOR BLADES

(71) We, THE GILLETTE COMPANY, a corporation organized under the laws of the State of Delaware, United States of America, of Gillette Park, Boston, State of Massachusetts, United States of America, do hereby declare the invention for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

This invention relates to the coating of safety razor blades.

Conventional steel safety razor blades which may be utilized in the practice of the present invention are from 0.0015 to 0.015 inch thick and have wedge shaped cutting edges that are formed with a series of precision grinding and/or honing operations. The steel of which such blade is composed may be either carbon steel or a hardenable corrosion resistant steel. In either case it is hardened by a suitable heat treating process and then sharpened to the wedge shaped cutting edge. The faces or sides of some such cutting edges extend back from the ultimate edge for a distance up to as much as 0.1 inch or even more. Each face need not be a single planar uninterrupted continuous surface or "facet", but may consist of two or more "facets" formed by successive grinding or honing operations and intersecting each other along zones generally parallel to the ultimate edge. The final facet, that is, the facet immediately adjacent the ultimate edge, may have a width as little as 0.0003 inch or even less. After the cutting edge is formed, further processing or treatment of the blade must be compatible with and not injurious to that edge.

It has long been known that a coating of a metal such as chromium on the cutting edge of a razor blade will increase the shaving life of the blade. Such a coating, however, should not have an adverse effect on other shaving characteristics of the blade. For example, we have found that a coating that is a large fraction of a micron in thickness impairs first shave quality. We have found that this metal film should not exceed 600 Angstroms in thickness , a preferable range being 50—500 Angstroms and best results being obtained with a range of 100—400 Angstroms thickness. This film should be continuous and of substantially uniform thickness. Further, from the standpoint of commercial practicability, this film should be applied with a method and appartaus that permits production of large quantities of razor blades with a minimum of additional processing steps.

According to the invention, there is provided a method of processing razor blades, comprising positioning a multiplicity of razor blades in a stack with their bodies in face to face contact and with their sharpened edges aligned with one another, and depositing a thin film of metal to a thickness of less than 600 Angstroms, preferably from 100 to 400 Angstroms, on said sharpened edges in a reduced pressure environment.

We also provide an apparatus for processing razor blades, comprising an evacuable chamber for providing an environment of reduced pressure, stack support structure for supporting a multiplicity of razor blades with their bodies in face to face contact and their sharpened edges aligned with one another in a stack, said stack support structure locating the stack of razor blades at a predetermined position in said chamber and defining an

exposure axis for said stack, a source of metal disposed along a line parallel to the exposure axis of said stack in said chamber and electrical circuitry for energizing said source of metal to deposit a thin film of said metal on the sharpened edges of said razor blades to form a thin adherent coating of metal on the sharpened edges of the razor blades in said stack.

Where the stack is in coil form, a mask is preferably employed to define an exposure axis of the stack. The source of metal preferably extends in non-uniform distribution along a line parallel to the exposure axis of the stack of blade edges as defined by the stack receiving structure, with portions of the source being disposed beyond each end of the blade stack so that the final facet of each blade is exposed to a portion of the source at an angle of at least 45°. This preferred non-uniform distribution of sources is due to the greater contribution to coating from the sources near the middle of the stack than from the source, beyond the end of the stack. The circuitry for energizing the source of metal preferably vaporizes a predetermined quantity of metal for application to the sharpened edges of the razor blades in the stack to form a thin continuous uniform coating of metal having a thickness of less than 600 Angstroms and preferably from 100 to 400 Angstroms that is firmly adherent on those sharpened edges. This film thickness may be measured by placing a drop (about 0.010 inch in diameter) of a concentrated sodium hydroxide solution on the metal film and electrolytically reverse plating until etching of individual carbides is detectable. The thickness of the film may then be measured with a Zeiss interference microscope employing a monochromatic light source.

The controlled distribution of the metal in the source parallel to the exposure axis and extending beyond the blade stack enables the deposition system to form a thin metal film uniformly on all the blades in the stack, which metal film is firmly adherent and which provides a suitable surface for receiving a shave facilitating polymer coating.

In particular embodiments of the apparatus, a plurality of blade stack support structures are arranged equidistantly from the source of metal and with the blade edges in each stack disposed at the same orientation with respect to the source of metal and at the same distance from that source of metal. The source of metal in those embodiments includes a series of discrete chromium plated tungsten wire elements formed in helical coils and non-uniformly spaced along the source line.

In one such embodiment, the blades are discrete blade elements and are stacked in face to face relationship on a stacking leaf which places their sharpened edges in exposed planar alignment and the position of the stacking leaf defines the exposure axis. In a second such embodiment, a length of ribbon blade is stacked in tightly wound coil form on a support plate so that the length of sharpened edge is in exposed planar alignment. In that embodiment the coil stack is mounted for rotation about an axis perpendicular to the exposure axis and a mask structure is disposed between the stack and the source of metal, which mask has an aperture dimensioned so that each portion of the stack is exposed to the source for an equal amount of time as the coil stack is rotated, the aperture being aligned with and defining the exposure axis.

In the practice of the method of the invention, the sharpened edges of a stack of clean blades, in a low pressure environment preferably of a pressure less than on half micron, may be coated by heating suitable plated metal source elements sufficiently to vaporize a predetermined amount of metal. In particular embodiments, the source elements are chromium plated tungsten wire coils which are heated sufficiently to vaporize all of the chromium. Thus a known amount of metal from a distributed source of particular configuration transfers metal to uniformly coat the sharpened edges of the blade load. By employing a series of six chromium plated twenty mil tungsten wire sources, the heating of the sources for a suitable period (as a function of electric current—typical periods ranging from twenty seconds to five minutes) vaporizes chromium to form an adherent coating on the blade edges. For example, heating the sources for a period of twenty seconds is sufficient to vaporize chromium to form an adherent blade edge coating of 100 Angstroms nominal thickness on a load of sixty thousand discrete blades. A coating 500 Angstroms in nominal thickness on such a load may be obtained by employing chromium plated thirty mil tungsten wire sources which are energized for two minutes. A coating that has a nominal thickness of 100 Angstroms may be formed on a five thousand foot length of razor blade strip stacked in a tightly wound coil by heating the sources for five minutes (two thirds of the coil stack being masked and the coil stack being continuously rotated during the deposition process).

In order to assure the adherence of the metal film to the sharpened edges of the razor blades, it is desirable that contamination on those surfaces be removed. Preferably at least part of this cleaning operation is carried out in the same reduced pressure environment as is employed for coating the razor blades. Cleaning may be carried out by various processes, for example, by heating the blades to a temperature of at least about 600°F. for six minutes in the reduced pres-

sure environment. Another arrangement, which is particularly compatible with the use of a plurality of blade stack support structures in a reduced pressure environment features a glow discharge arrangement for removing the contamination layer from the blade edges immediately prior to the application of the metal coating. A particular form of apparatus includes an elongated electrode member disposed within the evacuable chamber which has its axis extending parallel to the exposure axes of the blade stacks but other electode member configurations including use of the chamber wall itself may be satisfactorily employed. The chamber includes structure for introducing a glow discharge support gas into the chamber and electrical circuitry is provided for energizing the electrode member and the stack support structures as complementary electrodes to establish an electrostatic field between the electrode structure and the stacks of razor blades of sufficient magnitude to create a glow discharge condition at the exposed sharpened edges of the blades. The glow discharge condition preferably is established and maintained while the chamber is being evacuated at a high capacity pumping rate to remove, from the chamber, contaminants released from the blades under the influence of the glow discharge condition.

The blow discharge sustaining atmosphere is selected as a function of the material of the metal substrate such that no reaction product is formed on the substrate surface. Reducing or inert gases such as argon, hydrogen, nitrogen and helium are suitable. In particular embodiments hydrogen is used with a carbon steel razor blade while it is preferred to use an argon atmosphere with a corrosion resistant steel razor blade.

There is thus provided a particularly convenient method of cleaning the blades immediately prior to the deposition of metal and it enables the possible contamination of the cleaned blade edges after termination of the cleaning operation and before deposit of the metal to be minimized. After deposition of the metal coating on the blade edges, the stacks of blades may be removed from the vacuum chamber and further treated as for example through the deposition of a solid fluorocarbon polymer on the coated cutting edges. By practicing the invention, razor blades will be produced that exhibit characteristics of longer shaving life with blade stock formed from steels which consist of (by weight) from 0 to 1.4% carbon, from 0 to 18% chromium, from 0 to 2% molybdenum, from 0 to 2% silicon, from 0 to 8% nickel, with the balance being iron, apart from impurities; and such blades can thereby be processed in commercial quantities.

Specific steel compositions with which the invention may be practiced include the following:

Composition in %

C	Cr	Mo	Si	Ni
1.25	.2	—	.2	—
.96	13.9	—	.3	—
.65	10.5	1.0	.3	—
.58	14.0	—	.3	—
.40	13.5	1.25	.3	—
.09	17.0	.70	1.2	8.0

In order that the invention may be fully understood, it will now be described in conjunction with the accompanying drawings, in which:—

Fig. 1 is a sectional view of apparatus employed for cleaning the sharpened facets of a multiplicity of razor blades and depositing chromium on those facets;

Fig. 2 is a sectional view of the apparatus shown in Fig. 1 taken along the line 2—2 of Fig. 1;

Fig. 3 is a sectional view of a blade stack structure employed in the apparatus shown in Fig. 1 taken along the line 3—3 of Fig. 2;

Fig. 4 is a perspective view of a chromium plated tungsten wire coil and its support structure as employed in the apparatus shown in Fig. 1;

Fig. 5 is a perspective view of structure employed in the plating of chromium on a set of tungsten wire coils;

Fig. 6 is a schematic diagram of the electrical circuit employed in the blade cleaning operation;

Fig. 7 is a schematic diagram of the electrical circuit employed in the chromium deposition operation;

Fig. 8 is a diagrammatic view of the geometry of a preferred embodiment of the apparatus employed in the chromium deposition operation;

Fig. 9 is a diagrammatic plan view of a second form of apparatus constructed in accordance with the invention which apparatus includes structures for enabling both edges of double edged blades to be processed in the same evacuated environment in accordance with the invention.

Figs. 10 and 11 are diagrammatic side and top views of a second form of tungsten wire coil support structure useful in the type of apparatus shown in Fig. 9;

Fig. 12 is an elevational view (with parts broken away) of still another form of apparatus constructed in accordance with the invention for processing a razor blade component stacked in coiled form;

Fig. 13 is a sectional view taken along the line 1313 of Fig. 12;

Fig. 14 is a front view of a mask and coil stack structure employed in the apparatus shown in Fig. 12 taken generally along the line 1414 of Fig. 12; and

Fig. 15 is an enlarged elevational view (with superimposed sectional views) of a

chromium plated tungsten wire coil employed in the apparatus shown in Figs. 12—14.

The apparatus shown in Fig. 1 includes a base 10 which receives a glass bell jar 12 thirty inches in height and eighteen inches in diameter. The base 10 has a main exhaust port 14 to which is coupled a suitable vacuum system (not shown) that includes a liquid nitrogen trap and a high capacity diffusion pump. In a particular embodiment the pump has a pumping capacity of 2400 liters per second. A channel, diagrammatically indicated at 16, is provided for introducing a specific atmosphere into the chamber 18 formed between the bell jar 12 and the base 10 while the chamber is undergoing pumping by the vacuum system.

Mounted above base 10 on ring 20 are eighteen blade stack support structures 22, each of which defines an exposure axis. Ring 20 is supported from base 10 by six insulator posts 24 which are secured to ring 20 by screws 26. Each stack support structure 22 includes a main base member 28 of L-shaped configuration and a cooperating member 30 which is secured to member 28 by bolts 32, which cooperating members define between them a recess for receiving the lower end of a relatively rigid elongated blade aligning leaf or knife 34 on which a stack of razor blades is positioned. Base member 28 has a groove 36 in its upper horizontal surface which receives and positions the end of leaf 34. A thumb screw 38, threadedly received in member 30, is employed to clamp the aligning leaf 34 in the recess between members 28 and 30.

The aligning leaf support assembly is mounted on stud 40 which is spaced from ring 20 by an electrical insulating assembly of elements 42 and 44. An electrical connection via conductor 46 and stud 40 is made to the support block assembly and all of conductors 46 are connected to conductor 48 which passes through base 10.

Each blade support assembly 22 receives a leaf 34 which has secured to its opposite end a clamping block assembly 50 which includes members similar to members 28, 30. Between the two assemblies 22, 50 on each leaf 34 are positioned a stack of double edged razor blades 60 in a stack fourteen inches in length. In a typical processing of double edged blades in this apparatus each such stack has 3500 blades while in a typical processing of single edge injector type blades each such stack has 1400 blades. The aligning leaf structure 34 provides precise alignment of the edges 62 of the blades 60. Secured to the upper clamping assembly 50 is an alignment ring 64 which assures the alignment of the eighteen stacks of blades 60 relative to one another and the concentricity of those stacks within the bell jar 12.

Also mounted within bell jar 12 on base 10 are two aluminum electrode bars 70, 72 each twenty-four inches in length which are spaced from base 10 by insulators 74 and which are connected together by jumper 76 so that they are the same electrical potential when energized via conductor 78.

A distributed source of metal in the form of a series of six tungsten wire coils 80-1—80-6 are supported at fixed spaced locations along line 82 by two rods 84 which are mounted on horizontal bar members 86 which in turn are spaced from base 10 by insulated posts 88 to which are secured electrical conductors 90, 92, respectively. A series of mounting arm members 94 are secured to each rod 84 and each receives one end of coil 80 so that these coils are secured coaxially with line 82 at the center of the circle of stacks of blades 60. Also disposed on the base 10 over exhaust port 14 is baffle plate 96.

Electrode bars 70, 72 each extend equidistantly beyond either end of stacks of blades 60. The coils 80 are also symmetrically located with respect to the midpoints of the stacks of blades 60. The following table indicates satisfactory spacing for three different configurations of coils 80, groups I and II being sets of six coils and group III being a set of eight coils. The preferred spacing, indicated in Group I in the table below, is also represented in Fig. 8.

Spacing from Midpoint of Stack

	Coils 80-3,4	Coils 80-2,5	Coils 80-1,6	Coils x
I.	3-1/2″	10″	11-3/4″	
II.	3-3/4″	10-1/2″	11-3/4″	14″
III.	1-3/4″	3-3/4″	9-1/2″	

The geometry of a stack of blades 60 relative to the distributed source of coils 80 is indicated in Fig. 8. As indicated in Fig. 8, axis 82 is positioned a distance of six and three quarter inches from the edges 62 of the fourteen inch long stack of blades and parallel thereto. Along line 82 are disposed the six coils 80-1—80-6 according to the spacing set forth in group I in the table above. It will be seen that each facet of each blade is exposed to source at an angle of at least about 45° and the series of sources

overlap so that each final facet surface is exposed to at least two different sources of chromium.

Each coil 80 is a 2-15/16 inch length of twenty mil tungsten wire that is formed into a helix of four turns over an axial length of 1/2 inch. A lead 100, 3/4 inch in length is provided at each end of each coil. Each support bar 94 has a slot 102 in its end and the coil lead 100 is secured at the base of the slot by a set screw 104 which set screw provides electrical contact between the support arm 94 and the coil 80.

A layer of about thirty-eight milligrams of chromium is formed on each coil in the following manner. After the wire has been formed into a coil one lead 100 of each coil is connected to an aluminum disc 110 of configuration as indicated in Fig. 5. This disc is placed in a horizontal position in a plating bath and rotated at 100 rpm rate about axis 112.

A suitable plating bath is a chromic acid plating solution of the following composition:

4620 grams CrO_3
46.2 grams H_2SO_4, and
112 grams $Cr_2(SO_4)_3 \cdot 15\ H_2O$

This solution is diluted with distilled water to a quantity of five gallons.

In the plating operation the bath temperature is maintained at 110°F. and a plating current of eight amperes is maintained for eighteen minutes to plate each coil 80 with approximately 38 grams of chromium. If the leads 100 of the coils are not masked, the plating current may be increased slightly to compensate for the increased surface area being plated but otherwise the same process may be employed.

After the coils 80 have been plated with chromium six of them are secured to supports 94. A suitable process sequence is as follows: after carbon steel blades 60 of the following composition

carbon	1.15—1.30%
silicon	0.15—0.30%
manganese	0.25—0.50%
chromium	0.21—0.35%
sulfur	less than 0.45%
phosphorus	less than 0.45%
iron	remainder

have been cleaned thoroughly in trichloroethylene, they are formed on leaves 34 into eighteen stacks, each stack being fourteen inches in length, and the stacks are then positioned on the blade support structures 22 as indicated in Figs. 1 and 2. Aligning ring 64 is then bolted to the upper ends of the blade stacks so that those stacks are maintained equally spaced with respect to one another and concentric with respect to the axis 82.

The bell jar 12 is then placed on base 10 and the system is sealed and pumped at a rate of about 800 liters per second (after liquid nitrogen trapping and valving at base plate 10) until a vacuum of 0.1 micron is obtained. Hydrogen (as a glow discharge sustaining atmosphere) is then bled into the chamber 18 through inlet 16 until a chamber pressure of 200 microns is reached.

In the circuit arrangement the electrodes 70 and 72 are connected in parallel to terminal 78 as anodes as indicated in Fig. 6 and the eighteen stacks of blades 60 are connected in parallel to terminal 48 as cathodes. A voltage of 725 volts impressed across terminals 48, 78 establishes a glow discharge between the sharpened edges 62 of the blades 60 and the anodes 70, 72. An electric current flow of 925 milliamperes is maintained for seven minutes and the glow discharge condition acts on the contamination layer at the sharpened blade edges in a cleaning action. During this processing the pressure in the chamber increases to about 220 microns. At the end of seven minutes the glow discharge and the flow of hydrogen into the chamber are terminated. As pumping continues, the chamber pressure rapidly drops to 0.1 micron.

The six coils 80-1—80-6 are then energized via the circuit indicated in Fig. 7. The six tungsten coils, connected in parallel, are energized for twenty seconds with an electric potential of 8.8 volts and a current flow of 120 amperes, sufficient to heat the tungsten wires and vaporize all the chromium from the tungsten wires and transfer that chromium for deposit in a uniform film of controlled dimensions on the final facet of the sharpened edges 62 of the razor blades 60. The layer extends approximately 0.004 inch back from the ultimate edge and has a nominal thickness of about 100 Angstroms.

The chamber pumping is terminated and the pressure in the chamber is allowed to return to atmosphere so that the stacks of coated blades may be removed. After both sharpened edges 62 of the blades 60 have been coated with chromium, a polymer layer is applied to the chromium coated surfaces to provide a coating on top of the chromium layer. This polymer coating in a particular embodiment is a fluorocarbon polymer, applied to the cutting edges of the blade stack. This processing involves heating the blade to a temperature preferably in the range of 590°—806°F. and provides on the cutting edge of the razor blade an adherent coating of solid fluorocarbon polymer.

The heating condition, e.g. maximum temperature and length of time, obviously must be adjusted so as to avoid substantial decomposition of the polymer and/or ex-

cessive tempering of the metal of the cutting edge. In a preferred process, the polymer, in the form of dispersion of finely divided particles in an inert volatile liquid, is applied by spraying in a 40 kv electrostatic field to the sharpened cutting edges of the blade stack. The coated blades, which dry almost immediately due to the evaporation of the inert liquid, are then heated to a temperature from 590°—806°F. for two to fifteen minutes, e.g. to 650°F. for ten minutes in an atmosphere of hydrogen gas, after which the hydrogen is displaced by nitrogen while cooling the blades to 350°F. The blades are finally cooled in air from 350°F. to room temperature. Sixty thousand blade edges are satisfactorily processed in one chamber load with this apparatus and method. The blades processed in this manner exhibited a long shaving life.

In a second example, stainless steel blade of the following composition:

carbon	.54— .62%
chromium	13.5 —14.5 %
manganese	.20— .50%
silicon	.20— .50%
phosphorus, max.	.025%
sulphur, max.	.020%
nickel, max.	.50% max.
iron	remainder

were processed as follows. After hardening, sharpening and cleaning, eighteen blade stacks of 3500 blades each were placed in vacuum chamber 18. The chamber pressure was reduced to 0.1 micron and a discharge sustaining atmosphere of argon was then bled into the chamber to increase the pressure to 10 microns while a pumping rate of 800 liters per second after liquid nitrogen valving and trapping at the base plate was maintained. A glow discharge was initiated in this argon atmosphere at a voltage of 1600 volts with the circuit shown in Fig. 6 and a current flow of 900 milliamperes was maintained for eight minutes. The argon flow was then terminated and the pressure in the chamber rapidly dropped to 0.1 micron. The six coils 80 located as above described in group I then were energized to vaporize the chromium (an electric potential of 8.8 volts and an electric current of 120 amperes being maintained for twenty seconds). The resulting chromium coating had a nominal thickness of 100 Angstroms and extended along the entire cutting edge and back along the final facet for a length at least 0.001 inch. The fluorocarbon polymer coating was applied to the coated blades and those blades also exhibited characteristics of long life.

In a third example, employing corrosion resistant steel blades of composition similar to the above except for a carbon content of about 0.9% and a chromium content of about 14.5% eighteen stacks of thirty five hundred blades each were placed in chamber 18. Pressure was reduced to 1.0 microns by a constant pumping rate of 800 liters per second and then argon was introduced while pumping continued until the pressure increased to 10 microns. The circuitry shown in Fig. 6 was employed to initiate a glow discharge with an electric potential of 1600 volts and a current flow of 900 milliamperes which was maintained for four minutes. The argon flow was then terminated and when the chamber pressure had returned to less than 0.1 micon the filaments 80 were energized by a voltage of 8.8 volts, producing a current flow of 120 amperes for twenty seconds to vaporize all the chromium and form a film on the exposed edges of the blades 60. After removal of the blades from the chamber they were coated with a fluorocarbon polymer as above described. These blades also exhibited characteristics of long shaving life.

In a fourth example, eighteen stacks of single edge stainless steel blades 0.008 inch in thickness were placed in chamber 18, producing a total chamber load of about 25,000 blades. The pressure in the chamber was reduced to 0.1 micron by pumping rate of about 800 liters per second with liquid nitrogen trapping and valving at the base plate. Argon was then bled into the chamber until the chamber pressure reached 10 microns while the pumping rate continued and a glow discharge was initiated with the circuit shown in Fig. 6 by applying a voltage of 1600 volts and maintaining with a current of 900 milliamperes for eight minutes. The glow discharge and introduction of argon were then terminated and when the pressure in the chamber dropped to 0.1 micron, the coils 80 were energized at 8.8 volts and a current of 120 amperes for twenty seconds to vaporize all the chromium. The chromium coated blades were then removed from the chamber and a polymer coating as described above was applied to them. All the blades treated in the chamber passed quality control tests and exhibited characteristics of long shaving life.

In still another example, a vacuum chamber 18 is provided employing a stainless steel base 10 and a stainless steel bell jar 12. The anode electrodes 70, 72 were omitted and the base 10 was grounded and functioned as the anode in the circuit shown in Fig. 6. Razor blades of the same material as in the second example were placed in the chamber, producing a chamber load in excess of 60,000 blades. The pressure in the chamber was reduced to 0.1 micron by pumping at a rate about 800 liters per second with liquid nitrogen trapping and valving at the base plate. Argon was then bled into the chamber until the chamber pressure reached 10 microns

while the pumping rate was continued. A glow discharge was initiated, employing the base plate and bell jar as the anode by applying a voltage of about 1560 volts between the plate support structures and the chamber walls. A current of 925 milliamperes was maintained for seven minutes. The glow discharge and introduction of argon were then terminated and when the pressure in the chamber had dropped to 0.1 micron, the coils 80 were energized for twenty seconds at a potential of 8.8 volts and a current of 120 amperes to vaporize all the chromium. The chromium coated blades were then removed from the chamber and a polymer coating as described above was applied directly (as in the other examples) on the chromium surfaces without modification or other working of those surfaces. The blades treated in this manner also exhibited characteristics of long shaving life.

The diagrammatic representation of Fig. 9 illustrates an arrangement of a chamber 18′ in which the blade stacks support structures 22′ may be rotated 180° for successively coating both sharpened edges of double edge blades 60′ without the necessity of opening the vacuum chamber 18′. Each support structure 22′ is mounted for rotation and includes stops for positioning the blade stack support structure in accurate alignment so that the midpoints of the sharpened edges are tangent to a radius from the coil axis 82′. A ring drive 150 engages drive discs 152 secured to each support structure and as ring 150 is rotated discs 152 are driven frictionally to rotate these stack structures 22′ and the blades 60′ supported on these structures 180° to abut a series of precision stops. Electrode 70′ is also mounted on a rotatable drive disc 154 which rotates about the axis of electrode 70′. A second set of six coils 80′ are spaced along axis 156 on the opposite side of electrode 70′ from the coils 80 on axis 82′. After one set of sharpened edges of the blade stacks have been coated with chromium from coils 80 ring 150 and disc 154 are rotated by a suitable drive to turn discs 152 and 154, 180°. A glow discharge cycle and chromium vaporization cycle is then performed in sequence utilizing coils 80′. It will be noted that electrode 70′ shields the coils 80′ on axis 156 from the coils 80 on axis 82′ during the first deposition process.

A second form of support for two sets of coils 80 is indicated in Figs. 10 and 11. Three rods 84-1, 84-2 and 84-3 are employed, rods 84-2 and 84-3 being electrically insulated by a mica sheet 160. Two sets of six coils each (designated 80A and 80B, respectively), in horizontal orientation, are secured at fixed spaced locations (in Group I positions) along axis 82A; the coils 80A being vertically offset 7/8 inch from coils 80B. Rigid supports 162 project horizontally from rods 84 and receive the terminal portions of coils 80A, 80B, which terminals are secured by set screws 164. Only the center two turns of each coil are plated with chromium (each coil being plated with approximately thirty-eight grams of chromium). In operation, both edges of the blades are first cleaned by glow discharge (a single glow discharge as above described providing adequate cleaning of both edges); one set of sharpened edges is coated with chromium from coils 80A; the blade stacks are rotated; and then the second set of sharpened edges is coated with chromium from coils 80B.

Still another form of apparatus constructed in accordance with the invention is shown in Figs. 12—15. As indicated in Figs. 12 and 13 the apparatus includes a base 10″ which receives a bell jar 12″ thirty inches in height and twenty-four inches in diameter. Vacuum apparatus associated with the base 10″ may be identical with the apparatus described in connection with Figs. 1 and 2. Mounted above base 10″ are two blade stack support structures 202, 204, each of which includes a pedestal 206 on which is mounted a bearing housing 208. A drive shaft 210 extends through housing 208 and has a square end portion 212 which receives in driving relation a reel 214 that has a length of sharpened blade strip 216 coiled on its hub 218. The strip 216 is secured on the reel by a ring clamp 220 that is disposed about the periphery of the coil of blade strip. The reel 214 is secured on the square shaft end by a retaining disc, lock washer, and thumb screw 222. The bodies of the adjacent blade lengths on the reel are in contact with one another and their sharpened edges are aligned with one another at the face of the coil. The strip 216 is, of course, ultimately severed into suitable short lengths for use in band type razors and therefore in effect comprises a multiplicity of potential razor blades. The coiled strip 216 is exactly equivalent to the stock 60 of individual razor blades referred to in connection with Figure 1. In both arrangements, the bodies of the razor blades (actual or potential) are in face to face contact with their sharpened edges aligned with one another. In this embodiment the razor blade element 216 is a strip of stainless steel 0.0015 inch thick, 0.1895 inch wide and 5,000 feet long and of the following composition:

carbon	.37— .43%
chromium	13.0 —14.0 %
manganese	.20— .50%
molybdenum	1.15— 1.35%
silicon	.20— .50%
phosphorum, max.	.025%

sulphur, max.	.20%
nickel, max.	.50% max.
iron	remainder

Hub 218 has a radius of 1.875 inches and the outer edge of the coiled blade stack is 5.625 inches from the reel center.

Each drive shaft 210 is driven in rotation through stainless steel gearing 224 lubricated with molybdenum disulphide, vertical shaft 226 and external drive 228 which may be coupled to shaft 226 mechanically via a seal in base plate 10′ or by other suitable means such as a magnetic drive.

Extending laterally from the rear of each bearing housing 208 are two support arms 230, each of which has a polytetrafluoroethylene block 234 secured to it that projects forwardly to a point one-half inch in front of the plane of the forward surface of reel 214 on which the blade strip 216 is seated.

Disposed in front of each coil stack support structure and supported on blocks 234 is a generally circular aluminum mask 236, the configuration of which is best seen with the reference to Fig. 14. That mask has two oppositely extending generally pie shaped symmetrical apertures 238 which define exposure axis 240. The innermost section 242 of each aperture is triangular in configuration and exposes the hub 218 of the reel 214. Extending radially outwardly from section 242 are side walls 244 each of which is beveled to a smooth line surface as indicated in Fig. 13. The inner ends 246 of side walls 244 are spaced apart 1.385 inches and the outer ends 248 are spaced apart six inches at a point beyond the periphery of the blade stack 216. Mask 236 is mounted on blocks 234 by bolts 250 so that exposure axis 240 that bisects each aperture 238 is in vertical position and the center 252 of the mask is coincident with the axis of drive shaft 210.

Also mounted within bell jar 12″ on base 10″ are two aluminum electrode bars 70″, 72″ each twenty-four inches in length; and a distributed source of metal in the form of six tungsten wire coils 80-1″—80-6″ which are supported at fixed spaced locations along the line 82″ parallel to the exposure axes 240 defined by masks 236. It will be noted that this electrode and source arrangement is the same as described above in connection with Figs. 1 and 2. Each coil 80″ is a 2-15/16 inch length of twenty mil tungsten wire which is formed into a helix of four turns over an axial length of 1/2 inch. A lead 100″, three quarters of an inch in length, is provided at each end of the helix. A layer 258 of about one hundred fifteen milligrams of chromium is formed on the middle two turns 261, 262 of the helix by deposition in the above described plating bath for twelve coils (a plating current of sixteen amperes being maintained for fifty-five minutes) with the outer two turns 260, 263 and the leads 100′ appropriately masked (as indicated diagrammatically in Fig. 13).

In a typical process, six such plated coils 80″ are secured in the indicated spaced relation along axis 82″. Two reels 214, each holding a coiled stack of hardened, sharpened, and cleaned blades 216, are positioned on support structures 206 and the bell jar 12″ is positioned over the blade stacks. The two reels 214 are driven in rotation by drives 228 at a constant speed of about twenty rpm. Pressure in the chamber is reduced to 0.1 micron by a constant pumping rate of 800 liters per second and then while pumping is continued argon is introduced until the pressure increased to 10 microns. A glow discharge is then initiated in the argon atmosphere at a voltage of 1600 volts across a circuit between the support structures 206 and the anodes 70″, 72″. (The blades 216 are at the same electric potential as the support structures 206 but the masks 226 are insulated by the Teflon blocks 234). A current flow of three hundred milliamperes at a voltage of sixteen hundred volts is maintained for ten minutes in a glow discharge blade edge cleaning operation. The argon flow is then terminated and the pressure in the chamber rapidly drops to 0.1 micron. The two reels 214 are then driven at a speed of about three hundred rpm., and the six coils 80″, located as above described in group I, are energized to vaporize the chromium (an electric potential of seven volts and an electric current of one hundred thirty-two amperes being maintained for five minutes).

As a result of this process, a firmly adherent, chromium coating that had a nominal thickness of 100 Angstroms and that extended along the entire cutting edge and back from that cutting edge for a length of at least 0.001 inch was formed on the blades. After removal of the blade stacks from the chamber, the sharpened, coated edges of the blades were treated with a fluorocarbon polymer as above described. The ribbon blades from these coils as treated in this chamber passed quality control test and exhibited characteristics of long shaving life.

WHAT WE CLAIM IS:—

1. A method of processing razor blades, comprising positioning a multiplicity of razor blades in a stack with their bodies in face to face contact and with their sharpened edges aligned with one another, and depositing a thin film of metal to a thickness of less than 600 Angstroms, preferably from 100 to 400 Angstroms, on said sharpened edges in a reduced pressure environment.

2. A method according to claim 1, wherein

prior to the deposition of the thin film of metal the stack of razor blades is subjected to a cleaning operation to remove contamination from the sharpened edges, the cleaning operation being carried out in the reduced pressure environment.

3. Apparatus for processing razor blades, comprising an evacuable chamber for providing an environment of reduced pressure, stack support structure for supporting a multiplicity of razor blades with their bodies in face to face contact and their sharpened edges aligned with one another in a stack, said stack support structure locating the stack of razor blades at a predetermined position in said chamber and defining an exposure axis for said stack, a source of metal disposed along a line parallel to the exposure axis of said stack in said chamber, and electrical circuitry for energizing said source of metal to deposit a thin film of said metal on the sharpened edges of said razor blades to form a thin adherent coating of metal on the sharpened edges of the razor blades in said stack.

4. Apparatus according to claim 3, wherein said source of metal includes a plurality of discrete source elements disposed at a series of unequally spaced positions along said line.

5. Apparatus according to claim 4, wherein each discrete source element is a substrate structure coated with the metal to be deposited and said circuitry includes controls for energizing said elements to vaporize all of the coating metal.

6. Apparatus according to claim 5, wherein said coating metal is chromium and said razor blades are steel.

7. Apparatus according to claim 3, wherein said source of metal is of a length with respect to said stack of blades so that the final facet of each blade edge exposed to said source of metal is exposed to a portion of said source of metal at an angle of at least about 45°.

8. Apparatus according to claim 3, comprising means operative in said environment of reduced pressure for removing a contamination layer from the sharpened edges of said razor blades prior to the formation of said thin adherent coating of metal on said sharpened edges.

9. Apparatus according to claim 8, wherein the contamination layer removing means includes means to heat said blades to a temperature of at least 600°F.

10. Apparatus according to claim 8, wherein the contamination layer removing means includes means to establish a glow discharge at the sharpened edges of said razor blades in said environment of reduced pressure.

11. Apparatus according to claim 10, comprising an electrode structure, circuitry for connecting said stack support structure as a second electrode, and energizing circuitry for energizing said electrode structure and said stack support structure to create an electrostatic field in said environment of reduced pressure to establish a flow discharge condition at the sharpened edges of a stack of razor blades disposed on said stack support structure.

12. Apparatus according to claim 11, wherein said electrode structure is a wall portion of the evacuable chamber.

13. Apparatus according to claim 11, wherein said electrode structure is disposed within the evacuable chamber.

14. Apparatus according to claim 3, comprising a mask disposed between said stack support structure and said source of metal for defining said exposure axis of the stack.

15. Apparatus according to claim 3, wherein said stack support structure is adapted to receive a coiled stack of razor blades, and further including means for rotating said coiled stack of razor blades at a uniform rate when said stack is disposed on said stack support structure.

16. Apparatus according to claim 15, wherein said source of metal includes a plurality of discrete source elements disposed at a series of unequally spaced positions along said line, each said source element being a coil of tungsten wire plated with chromium, and said circuitry further includes control for energizing said source of metal to vaporize all of said coating metal and said source elements being disposed with respect to said stack of blades so that the final facet of each blade edge exposed to said source is exposed to at least one source element at an angle of at least about 45°.

17. Apparatus according to claim 16, comprising means operative in said environment of reduced pressure for removing a contamination layer from the sharpened edges of said razor blades prior to the formation of said thin adherent coating of metal on said sharpened edges.

18. Apparatus according to claim 17, wherein said contamination layer removing means includes means to establish a glow discharge at the sharpened edges of said razor blades in said environment comprising an electrode structure, circuitry for connecting said stack support structure as a second electrode, and energizing circuitry for energizing said electrode structure and said stack support structure to create an electrostatic field in said environment of reduced pressure to establish a glow discharge condition at the sharpened edges of the stacks of razor blades disposed on said stack support structure.

19. Apparatus according to claim 18, wherein a mask is disposed between said stack support structure and said source of

metal for defining the exposure axis of said stack.

20. Apparatus according to claim 3, comprising a plurality of stack support structures equidistantly spaced from said source of metal, each said stack support structure being adapted to support a coil of razor blades for rotation about an axis perpendicular to the plane of the sharpened edges of said blades in said coil and perpendicular to the exposure axis of the support structure.

21. Apparatus according to claim 3, wherein said source of metal includes a plurality of discrete source elements disposed at a series of unequally spaced positions along said line, each said source element being a coil of tungsten wire having its center portion plated with chromium and the terminal portions on either side of said center portion unplated.

22. Apparatus according to claim 3, comprising a plurality of stack support structures equidistantly spaced from said source of metal, each of said stack support structure defining said exposure axis and supporting a stack of razor blades along a path parallel to said line with the midpoints of the sharpened edges tangent to a radius from said line.

23. Apparatus according to claim 22, wherein said source of metal includes a plurality of discrete source elements disposed at a series of unequally spaced positions along said line, each said source element being a coil of tungsten wire plated with chromium, and said circuitry further includes control for energizing said source of metal to vaporize all of said coating metal and said source elements being disposed with respect to said stacks of blades so that the final facet of each blade edge exposed to said source is exposed to at least one source element at an angle of at least about 45°.

24. Apparatus according to claim 23, comprising means operative in said environment of reduced pressure for removing a contamination layer from the sharpened edges of said razor blades prior to the formation of said thin adherent coating of metal on said sharpened edges.

25. Apparatus according to claim 24, wherein the contamination layer removing means includes means to establish a glow discharge at the sharpened edges of said razor blades in said environment comprising an electrode structure, circuitry for connecting said stack support structure as a second electrode, and energizing circuitry for energizing said electrode structure and said stack support structure to create an electostatic field in said environment of reduced pressure to establish a glow discharge condition at the sharpened edges of the stacks of razor blades disposed on said stack support structures.

26. A method of processing razor blades substantially as herein described with reference to Figures 1 to 8, Figures 9 to 11, or Figures 12 to 15 of the accompanying drawings.

27. Apparatus for processing razor blades, constructed and arranged substantially as herein described with reference to Figures 1 to 8, Figures 9 to 11, or Figures 12 to 15 of the drawings.

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FIG I

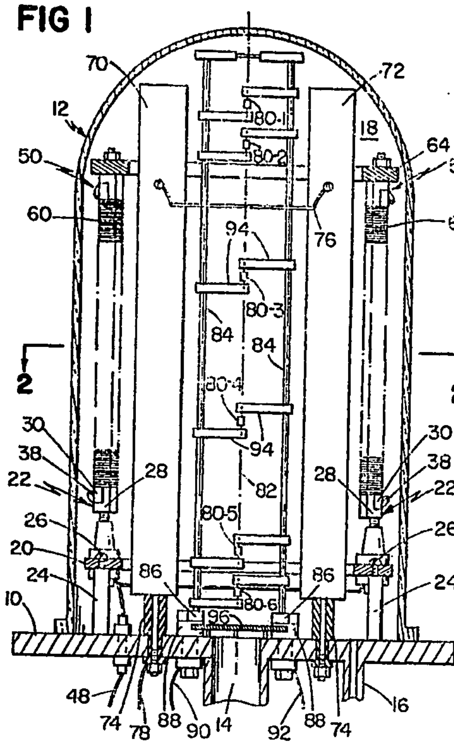
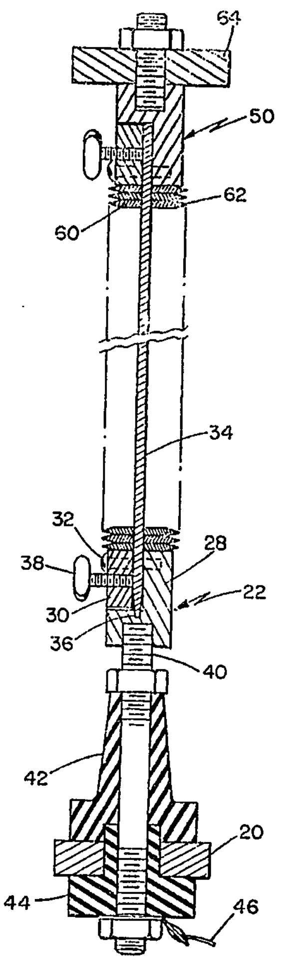


FIG 3



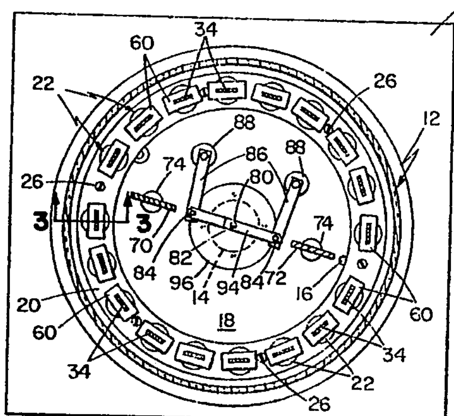
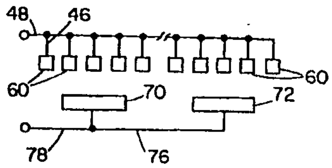


FIG 2

FIG 6



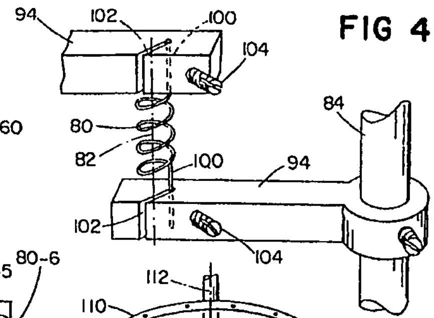


FIG 4

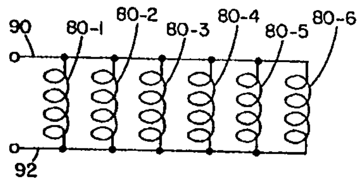


FIG 7

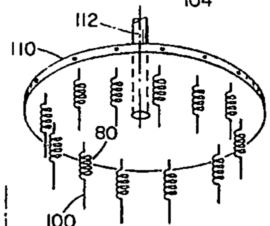


FIG 5

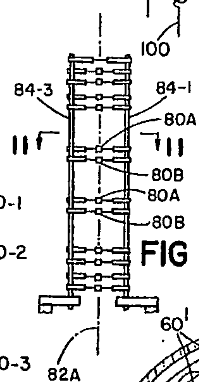


FIG 10

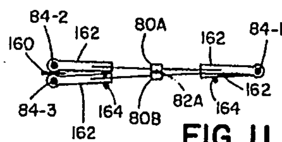


FIG 11

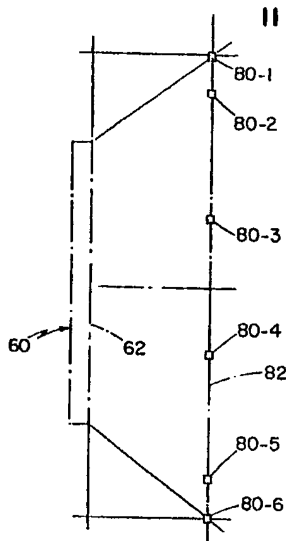


FIG 8

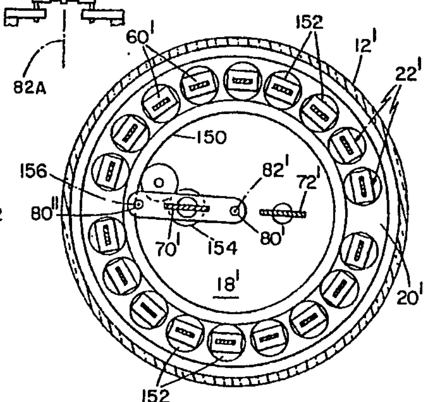
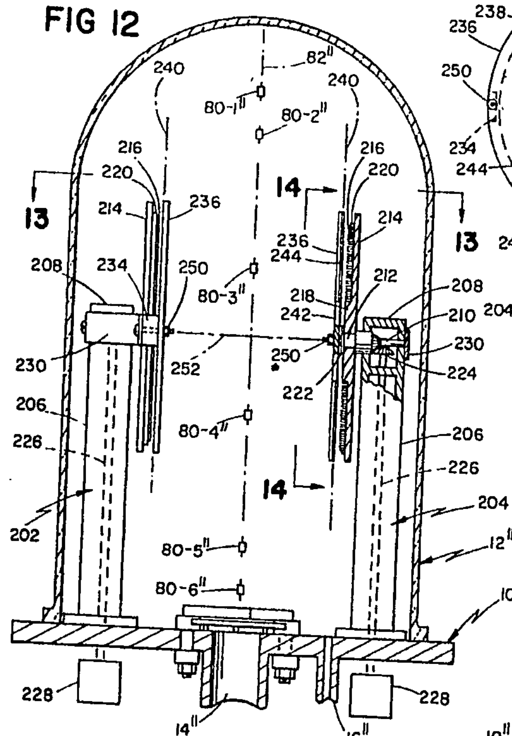


FIG 9

FIG 12



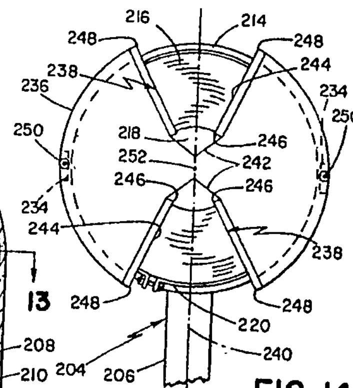


FIG 14

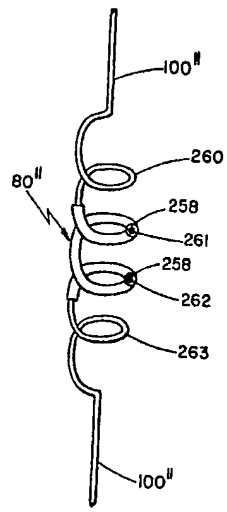


FIG 15

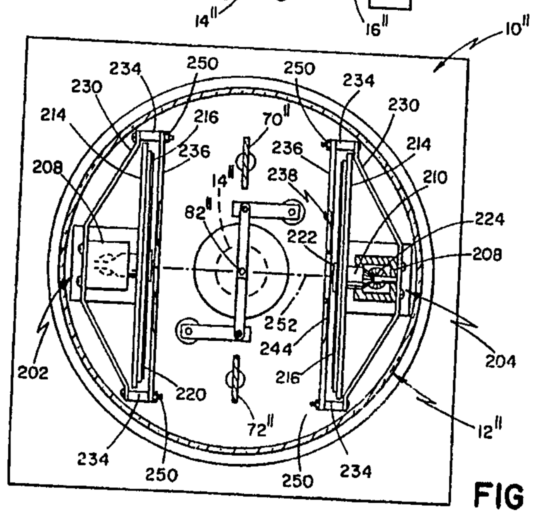


FIG 13